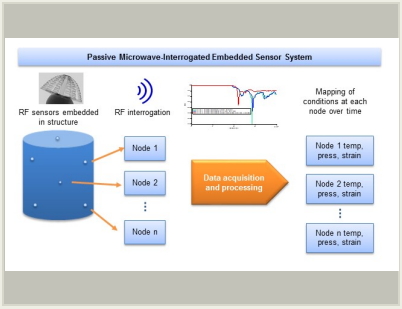
Microwave-Interrogated Embedded Sensor System for Nondestructive Evaluation (NDE) of Complex Structures, Phase I

Completed Technology Project (2017 - 2017)

Project Introduction

Makel Engineering, Inc. and Lawrence Livermore National Lab propose to develop a new class of microwave-interrogated embedded sensors for nondestructive evaluation (NDE) of complex structures. Three-dimensional sensors will be formed by additive manufacturing technology and will employ advanced sensing materials for accurate measurement of structural integrity. Microwaves are a particularly effective and versatile probe for complex structures because they readily penetrate a wide range of solid materials. At the highest frequencies (~100 GHz), wavelengths can approach the 1 mm scale, allowing for the possibility of sub-millimeter embedded sensor size, since resonant features can be scaled smaller than the interrogating wavelength. Structural health can therefore be unobtrusively measured and mapped from locations distributed over a defined volume of material or over a wide area. A potential issue associated with any physical sensor is the size of the sensor relative to the minimum dimensions of the structures being measured. Our team can develop microwave-interrogated sensors with diameters smaller than 1 mm that can be embedded in structures. Electrically small 3D antennas coupled with capacitive or piezoresistive materials are embedded structural component. The passive antennas are interrogated by sweeping frequencies in the microwave range. Pressure and temperature changes in the system are observed by the corresponding changes in resonant frequency of the antenna due to capacitance changes in the sensor material, and captured by the reflected energy spectra. The sensor in each node has a unique characteristic frequency, enabling mapping the response to a specific node location, and simultaneous characterization of multiple sensors with a frequency sweep. Data acquisition and processing software is used to convert spectral response into changes in temperature, pressure or other measured variables, and to map conditions at each node over time.



Microwave-Interrogated Embedded Sensor System for Nondestructive Evaluation (NDE) of Complex Structures, Phase I Briefing Chart Image

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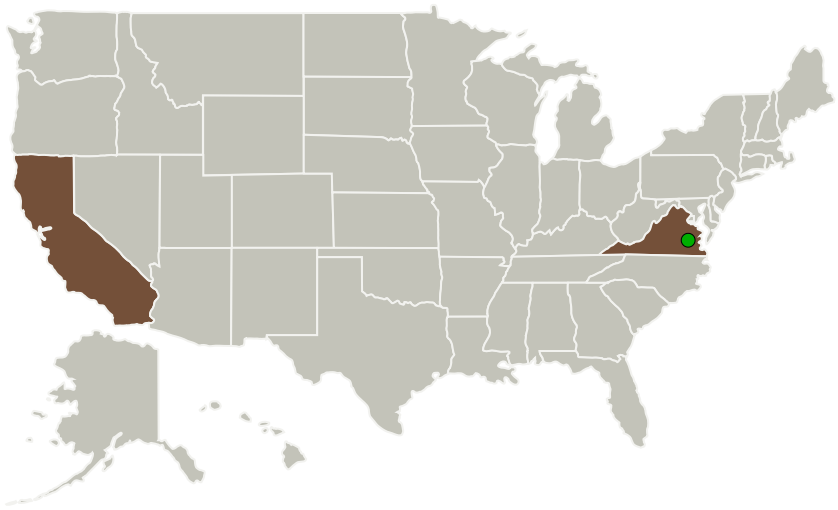
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Makel Engineering, Inc.	Lead Organization	Industry Small Disadvantaged Business (SDB)	Chico, California
Langley Research Center(LaRC)	Supporting Organization	NASA Center	Hampton, Virginia

Primary U.S. Work Locations	
California	Virginia

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Makel Engineering, Inc.

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

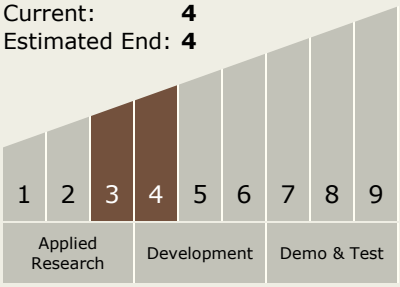
Carlos Torrez

Principal Investigator:

Darby B Makel

Technology Maturity (TRL)

Start: **3**
Current: **4**
Estimated End: **4**



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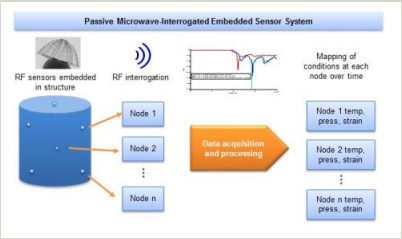
Images



Briefing Chart Image
Microwave-Interrogated Embedded Sensor System for Nondestructive Evaluation (NDE) of Complex Structures, Phase I Briefing Chart Image
(https://techport.nasa.gov/image/127295)

Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.3 In-Situ Instruments and Sensors
    - TX08.3.1 Field and Particle Detectors

Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System